

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>C09B 67/00, A61K 7/13</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 97/19999</b> <b>(43) International Publication Date:</b> 5 June 1997 (05.06.97)
<b>(21) International Application Number:</b> PCT/DK96/00499 <b>(22) International Filing Date:</b> 29 November 1996 (29.11.96) <b>(30) Priority Data:</b> 1357/95                      30 November 1995 (30.11.95)    DK <b>(71) Applicant (for all designated States except US):</b> NOVO NORDISK A/S [DK/DK]; Novo Allé, DK-2880 Bagsværd (DK). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> AASLYNG, Dorrit [DK/DK]; Novo Nordisk A/S, Novo Allé, DK-2880 Bagsværd (DK). SØRENSEN, Niels, Henrik [DK/DK]; Novo Nordisk A/S, Novo Allé, DK-2880 Bagsværd (DK). RØRBÆK, Karen [DK/DK]; Novo Nordisk A/S, Novo Allé, DK-2880 Bagsværd (DK). <b>(74) Common Representative:</b> NOVO NORDISK A/S; Novo Allé, DK-2880 Bagsværd (DK).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> LACCASES WITH IMPROVED DYEING PROPERTIES  <b>(57) Abstract</b> <p>The present invention relates to a permanent dyeing composition comprising: a) above 0 to 1 mg enzyme protein per ml dyeing composition of microbial laccase, b) one or more dye precursor, and c) optionally one or more dye modifiers, the use of the dyeing composition for dyeing keratinous fibres, such as hair, fur, hide and wool, and a method for permanent dyeing of keratinous fibres.</p>		

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**Title:** Laccases with improved dyeing properties

**FIELD OF THE INVENTION**

5 The present invention relates to a dyeing composition comprising a microbial laccase, the use of said dyeing composition for dyeing keratinous fibres, in particular hair, fur, hide and wool, and a method for dyeing keratinous fibres.

10 **BACKGROUND OF THE INVENTION**

It has been used for many years to dye the hair to cover appearing grey hair. The need to do so arises from the fact that grey hair is the first sign of having past adolescence, which can be hard to accept for many people.

15 For instance, in certain parts of Asia it is widely used by both men and women to dye the hair with dyes often referred to by humorous people as "black shoe polish".

During the last few decades hair dyeing has become more and more popular in the western world. At first Punk Rockers and  
20 other society critical groups dyed their hair in extreme colours as a part of their protest against the established society, but today especially many young people also uses hair dyes (in more soft tints than the Punk Rockers) as a sort of "cosmetic" to change or freshen up their "look".

25

Hair dyes

In general hair dyeing compositions on the market today can be divided into three main groups:

- temporary hair dyes,
- 30 - semi-permanent hair dyes, and
- permanent oxidative hair dyes.

The temporary hair dyes are only intended to change the natural hair colour for a short period of time and usually functions by depositing dyes on the surface of the hair. Such  
35 hair dyes are easy to remove with normal shampooing.

When using semi-permanent hair dyes the colour of the dyed hair can survive for five or more shampooings. This is achieved

by using dyes having a high affinity for hair keratin and which is able penetrate into the interior of the hair shaft.

Permanent hair dyes are very durable to sunlight, shampooing and other hair treatments and need only to be refreshed once a month as new hair grows out. With these dyeing systems the dyes are created directly in and on the hair. Small aromatic colourless dye precursors (e.g. p-phenylene-diamine and o-aminophenol) penetrate deep into the hair where said dye precursors are oxidised by an oxidising agent into coloured polymeric compounds. These coloured compounds are larger than the dye precursors and can not be washed out of the hair.

By including compounds referred to as modifiers (or couplers) in the hair dyeing composition a number of hair colour tints can be obtained. Cathecol and Resorcinol are examples of such modifiers.

Traditionally  $H_2O_2$  is used as the oxidizing agent (colour builder), but also as a bleaching agent. Dyeing compositions comprising  $H_2O_2$  are often referred to as "lightening dyes" due to this lightening effect of  $H_2O_2$ .

The use of  $H_2O_2$  in dyeing compositions have some disadvantages as  $H_2O_2$  damages the hair. Further, oxidative dyeing often demands high pH (normally around pH 9-10), which also inflicts damage on the hair and on the skin. Consequently, if using dye compositions comprising  $H_2O_2$  it is not recommendable to dye the hair often.

To overcome the disadvantages of using  $H_2O_2$  it has been suggested to use oxidation enzymes to replace  $H_2O_2$ .

US patent no. 3,251,742 (Revlon) describes a method for dyeing human hair by dye formation *in situ* (i.e. on the hair). An oxidative enzyme is used to the colour formation reactions at a substantially neutral pH (7-8.5). Laccases, tyrosinases, polyphenolases and catacolases are mentioned as suitable oxidation enzymes. The only exemplified oxidation enzyme is tyrosinase.

EP patent no. 504.005 (Perma S.A.) concerns dyeing compositions for keratinous fibres, in particular hair, which do not require the presence of  $H_2O_2$  (hydrogen peroxide). The

composition comprises an enzyme capable of catalysing the formation of the polymeric dyes and also dye precursors, such as bases and couplers, in a buffer solution wherein the pH of said composition is between 6.5 and 8 and said enzyme has an  
5 optimal activity in the pH range between 6.5 and 8.

*Rhizoctonia praticola* laccase and *Rhus vernicifera* laccase are the only laccases exemplified in the patent.

Abstract of Papers American Chemical Society vol. 209, no. 1-2, 1995 discloses the cloning of laccases from *Scytalidium*  
10 *thermophilum* and *Myceliophthora thermophila*. The abstract does not mention the use of said laccases for dyeing.

#### SUMMARY OF THE INVENTION

The object of the present invention is to provide improved  
15 dyeing compositions for keratinous fibres, such as hair, fur hide and wool, comprising an oxidative enzyme as the oxidising agent.

In the context of the present invention an "improved" composition for dyeing keratinous fibres means a composition  
20 being capable of dyeing the keratinous fibres in question faster or by the use of a smaller amount of oxidation enzyme to obtain an optimal dyeing effect, determined as  $\Delta E^*$ , in comparison to corresponding prior art dyeing compositions.

Further, it is also possible to use a less amount of dye  
25 precursor. This is advantageous as certain dye precursors are very unhealthy and very carcinogenic.

Compositions capable of dyeing the keratinous fibres, in particular hair, fur, hide and wool, faster are desirable as such compositions are very user convenient.

30 Further, it is desirable to be able to use a less amount of enzyme in the dyeing composition. This might make the dyeing process more economical. Further, the risk for creating airborne protein aerosols is reduced.

It has now surprisingly been found that it is possible to  
35 provide such improved dyeing compositions for keratinous fibres by using microbial laccases for oxidising the dye precursor(s).

Laccases (benzenediol:oxygen oxidoreductases) (E.C. class

1.10.3.2 according to Enzyme Nomenclature (1992) Academic Press, Inc.) are multi-copper containing enzymes that catalyse the oxidation of phenols. Laccase-mediated oxidation results in the production of aryloxy-radical intermediates from suitable phenolic substrates; the ultimate coupling of the intermediates so produced provides a combination of dimeric, oligomeric, and polymeric reaction products. Certain reaction products may be used to form dyes suitable for dyeing keratinous fibres, such as hair and wool (see below).

10 Firstly, the object of the invention is to provide a dyeing composition comprising

a) above 0 to 1 mg enzyme protein per ml dyeing composition of microbial laccase,

b) one or more dye precursors,

15 c) optionally one or more modifiers.

Specifically contemplated is laccases of microbial origin, derived from a strain of the genus *Myceliophthora*.

In the second aspect the invention relates to the use of a dyeing composition of the invention for dyeing keratinous fibres, such as hair, fur, hide and wool.

20 The invention also related to a method for dyeing keratinous fibres comprising contacting the dyeing composition of the invention to the keratinous fibres in question under suitable conditions and for a period of time sufficient to permit oxidation of the dye precursor into a coloured compound.

25 The invention also relates to the use of a laccase for permanent dyeing of keratinous fibres wherein said laccase is a laccase that results in a  $\Delta E^*$ -value higher than the  $\Delta E^*$ -value resulting from a laccase derived from *Rhus* under corresponding dyeing conditions.

30 This means that when dyeing keratinous fibres with a dyeing composition of the present invention the  $\Delta E^*$ -value determined are higher than the  $\Delta E^*$ -value determined from corresponding keratinous fibres dyed under the same conditions using a dyeing composition comprising a laccase derived from *Rhus*.

35 The term "corresponding dyeing conditions" means under conditions where e.g. the enzyme concentration or enzyme

activity, dyeing incubations time, dyeing incubation temperature, pH conditions, keratin fibre type (such as hair type) are the same, and further that the same dye precursor(s) and modifier(s) are used. In other words it defines conditions parallel to the specific dyeing conditions chosen. The dyeing conditions described below in the Examples may be chosen.

In the context of the present invention a "higher"  $\Delta E^*$  value defines that the total quantitative colour change is more than one  $\Delta E^*$  unit.

$\Delta E^*$  is calculated from the values of the parameters  $a^*$ ,  $b^*$  and  $L^*$  determined e.g. on a Minolta CR200 Chroma Meter using the formula  $\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$ . The meaning of  $a^*$ ,  $b^*$  and  $L^*$  is explained below in the "Materials and Methods" section.

#### BRIEF DESCRIPTION OF THE DRAWING

Figure 1 shows the dyeing effect of six different laccases. The six laccases are the *Polyporus pinsitus* laccase (rPp-laccase), *Myceliophthora thermophila* laccase (Mt-laccase wt.), *Myceliophthora thermophila* T1 variant laccase (Mt-laccase (var)), *Rhus vernicifera* laccase (Rvl-FXu-1), *Scytalidium thermophilum* laccase (rStL-FXu-1) and *Rhizoctonia solani* laccase (rRsL-3-FXu-1). o-aminophenol is used as the dye precursor and m-phenylene-diamine is used as a modifier.

Figure 2 shows the wash stability of the *Myceliophthora thermophila* T1 variant laccase (Mt-laccase (var)) and the *Polyporus pinsitus* laccase (rPp-laccase) as the oxidising agent.

Figure 3 shows the fastness (speed) of hair dyeing using the *Myceliophthora thermophila* T1 variant laccase (Mt-laccase (var)) and the *Polyporus pinsitus* laccase (rPp-laccase) as the oxidising agent.

Figure 4 shows the dose-response dyeing effect of *Myceliophthora thermophila* laccase, using from 0.0001 to 0.5 mg enzyme protein per ml dyeing composition.

## DETAILED DESCRIPTION OF THE INVENTION

The object of the present invention is to provide improved dyeing compositions for permanent dyeing of keratinous fibres, such as hair, fur, hide and wool, comprising an oxidation enzyme.

It has now surprisingly been found that it is possible to provide such improved dyeing compositions by using a microbial laccase for oxidising the dye precursor(s).

### 10 The Dyeing Composition

In the first aspect the present invention relates to a dyeing composition comprising

- a) above 0 to 1 mg enzyme protein per ml dyeing composition of microbial laccase,
- 15 b) one or more dye precursor, and
- c) optionally one or more dye modifiers.

In a preferred embodiment of the invention the laccase may be present in the dyeing compositions in a concentration within the range from 0.0001 to 1 mg/ml, preferably 0.001 to 0.8 mg/ml, more preferred 0.002 to 0.5, even more preferred 0.003 to 0.2, especially 0.004 to 0.1 mg enzyme protein/ml dyeing composition.

When dyeing with a composition of the invention for permanent dyeing the  $\Delta E^*$ -value obtained is higher than that obtained when using a dyeing composition comprising a laccase derived from *Rhus* under corresponding dyeing conditions.

An example of a *Rhus* laccase is the laccase derived from the Japanese varnish tree *Rhus vernicifera* (Yoshida, (1883), J. Chem. Soc., 472). The *Rhus vernicifera* laccase is used in the Example 1 below.

The microbial laccase used according to the invention is of fungal or bacteria origin, in particular of filamentous fungus origin.

In an embodiment of the invention the microbial laccase is derived from a strain of genus *Myceliophthora*, such as a strain of the species *Myceliophthora thermophila* e.g. the purified laccase described in WO 95/33836 (PCT/US95/06815) from Novo



Nordisk, which is hereby incorporated by reference. SEQ ID NO 1 below shows a DNA sequence encoding a suitable laccase derivable from *Myceliophthora thermophila*.

5 *E. coli* JM101 containing the expression vector pRaMB5 comprising SEQ ID NO 1 has been deposited under the Budapest Treaty with the Agricultural Research Service Patent Culture Collection, Northern Regional Research Center, 1815 University Street, Peoria, Illinois, 61604. The vector have been given the Accession Number NRRL B-21261.

10 Also contemplated according to the invention are laccases derived from other micro-organisms being more than 80% homologous to SEQ ID NO 1 derived from *Myceliophthora thermophila*.

In addition, *Myceliophthora* laccases also encompass alternative forms of laccases which may be found in *M. thermophila* and  
15 as well as laccases which may be found in other fungi which are synonyms of fall within the definition of *M. thermophila* as described by Apinis (Nova Hedwigia 5, 57-78, 1963) and named *Sporotrichum thermophile*. Subsequent taxonomic revisions have placed this organism in the genus *Chrysosporium* (Von Klopotek,  
20 A. Arche., (1974) Microbiol, 98, 365-369) and later *Myceliophthora* (Van Oorshot, Persoonia, (1977), 9, 401-408). A number of organisms known by other named also appear to belong to this species. These include *Sporotrichum cellulophilum* (US patent no. 4,106,989); *Thielavia thermophila* (Fergus and Sinden  
25 (1968), Can. J. Botany, 47, 1635-1637); *Chrysosporium fergusi* and *Corynascus thermophilus* (Von Klopotek, supra).

Also the use of laccase variants are contemplated according to the present invention.

An example of a laccase variant is the *Myceliophthora thermophila* T1 variant described in PCT/US96/14087 (Novo Nordisk).  
30

T1 variants (or Type I variants) are modified blue copper oxidases, including laccases. T1 variants can for instance be constructed by site-directed mutagenesis and differ from the corresponding wild-type blue copper oxidases by at least one  
35 amino acid residue in the Type I (T1) copper site. These modifications generally result in altered pH profiles and/or specific activity relatively to the wild-type enzymes. This can

be advantageous when using the enzyme in question in dyeing compositions.

More specific the *Myceliophthora thermophila* T1 laccase variant may comprise the sequence 509VSGGL511 or may be  
5 modified as to increase the negative charge in at least one segment of the T1 copper site.

The above mentioned microbial laccases may advantageously be used in permanent dyeing composition for keratinous fibres. Such compositions have a superior dyeing effect to  
10 corresponding compositions comprising e.g. the *Rhus vernicifera* laccase as shown in Example 1.

The *Myceliophthora thermophila* T1 variant laccase is more wash stabile and further dyes faster than the *Polyporus pinsitus* laccase which is proven in Example 2 and Example 3, respec-  
15 tively.

Example 4 shows that less *Myceliophthora* laccase activity (i.e. LACU/ml) is needed to obtain a suitable dyeing effect in comparison to the *Polyporus pinsitus* laccase.

Example 5 shows that for the *Myceliophthora thermophila* laccase the dyeing effect optimum is obtained around 0.005 mg  
20 enzyme protein per ml dyeing composition.

In the case of using a *Myceliophthora* laccase in a permanent dyeing composition it may advantageously be present in concentrations from above 0 to 1 mg/ml, preferably 0.0001 to  
25 0.1 mg/ml, more preferably 0.0005 to 0.05 mg/ml, especially 0.001 to 0.01 mg enzyme protein per ml dyeing composition.

It is to be understood that the laccase may be produced either homologously, or heterologously in a host cell such as filamentous fungus, yeast or bacteria.

30 Examples of filamentous fungi host cells include strains of the species of *Trichoderma*, preferably a strain of *Trichoderma harzianum* or *Trichoderma reesei*, or a species of *Fusarium*, or a species of *Aspergillus*, most preferably *Aspergillus oryzae* or *Aspergillus niger*, or yeast cells, such as e.g. a strain of  
35 *Saccharomyces*, in particular *Saccharomyces cerevisiae*, *Saccharomyces kluyveri* or *Saccharomyces uvarum*, a strain of *Schizosaccharomyces* sp., such as *Schizosaccharomyces pombe*, a

strain of *Hansenula* sp., *Pichia* sp., *Yarrowia* sp., such as *Yarrowia lipolytica*, or *Kluyveromyces* sp., such as *Kluyveromyces lactis*, or a bacteria, such as gram-positive bacteria such as strains of *Bacillus*, such as strains of *B. subtilis*, *B. Li-*  
 5 *cheniformis*, *B. lentus*, *B. brevis*, *B. stearothermophilus*, *B. alkalophilus*, *B. amyloliquefaciens*, *B. coagulans*, *B. circulans*, *B. lautus*, *B. megaterium* or *B. thuringiensis*, or strains of -  
*Streptomyces*, such as *S. lividans* or *S. murinus*, or gram-nega-  
 tive bacteria such as *Escherichia coli*.

10 To obtain dyeing of the keratinous fibres the dyeing composition of the invention comprises one or more dye precursors which is(are) converted into coloured compound(s) by an oxidation agent which according to the present invention is a microbial laccase.

15 Without being limited thereto the dye precursor(s) may be (an) aromatic compound(s) belonging to one of three major chemical families: the diamines, aminophenols (or aminonaphtols) and the phenols. Examples of isatin derivative dye precursors can be found in DE 4,314,317-A1. Further, a number  
 20 of indole or indoline derivative dye precursors are disclosed in WO 94/00100. Said dye precursors mentioned in these documents are hereby incorporated herein by reference.

Examples of suitable dye precursors include compounds from the group comprising p-phenylene-diamine (PPD), p-toluylene-diamine (PTD), chloro-p-phenylene-diamine, p-aminophenol, o-ami-  
 25 nophenol, 3,4-diaminotoluene, 2-methyl-1,4-diaminobenzene, 4-methyl-o-phenylenediamine, 2-methoxy-p-phenylenediamine, 2-chloro-1,4-diamino-benzene, 4-amino diphenylamine, 1-amino-4- $\beta$ -methoxyethylamino-benzene, 1-amino-4-bis-( $\beta$ -hydroxyethyl)-am-  
 30 nibenzene, 1-3-diamino-benzene, 2-methyl-1,3-diamino-benzene, 2,4-diaminotoluene, 2,6-diaminopyridine, 1-hydroxy-2-amino-benzene, 1-hydroxy-3-amino-benzene, 1-methyl-2-hydroxy-4-amino-benzene, 1-methyl-2-hydroxy-4- $\beta$ -hydroxyethylamino-benzene, 1-hydroxy-4-amino-ebnzene, 1-hydroxy-4-methylamino-benzene, 1-me-  
 35 thoxy-2,4-diamino-benzene, 1-ethoxy-2,3-diamino-benzene, 1- $\beta$ -hydroxyethyloxy-2,4-diamino-benzene, phenazines, such as 4,7-

phenazinedicarboxylic acid, 2,7-phenazinedicarboxylic acid, 2-phenazinecarboxylic acid, 2,7-diaminophenazine, 2,8-diaminophenazine, 2,7-diamino-3,8-dimethoxyphenazine, 2,7-diamino-3-methoxyphenazine, 2,7-diamino 3-methoxyphenazine, 3-dimethyl  
5 2,8-phenazinediamine, 2,2'-[(8-amino-7-methyl-2-phenazinylo-  
imino]bis-ethanol, 2,2'-[(8-amino-7-methoxy-2-phenazinylo-  
imino]bis-ethanol, 2,2'-[(8-amino-7-chloro-2-phenazinylo-  
imino]bis-ethanol, 2-[(8-amino-7-methyl-2-phenazinylo-  
amino]-ethanol, 2,2'-[(8-amino-2-phenazinylo-  
imino]bis-ethanol, 3-amino-7-(dime-  
10 thylamino)-2,8-dimethyl-5-phenyl-chloride, 9-(diethylamino)-  
benzo[a]phenazine-1,5-diol, N-[8-(diethylamino)-2-phenazinylo-  
methanesulfonamide, N-(8-methoxy-2-phenazinylo-  
methanesulfonamide, N,N,N',N'-tetramethyl-2,7-phenazinediamine, 3,7-dime-  
thyl-2-phenazinamine, p-amino benzoic acids, such as p-amino  
15 benzoic acid ethyl, p-amino benzoic acid glycerid, p-amino  
benzoic acid isobutyl, p-dimethylamino benzoic acid amil, p-  
dimethylamino benzoic acid octyl, p-diethoxy amino benzoic  
amil, p- dipropoxy amino benzoic acid ethyl, acetylsalicylic  
acid, isatin derivatives, such as 2,3-diamino benzoic acid.

20 In an embodiment the laccase is used with the dye precursor  
directly to oxidise it into a coloured compound. The dye  
precursor may be used alone or in combination with other dye  
precursors.

It is believed that when using a diamine or an aminophenol  
25 as the dye precursor at least one of the intermediates in the  
co-polymerisation must be an *ortho*- or *para*-diamine or amino-  
phenol. Examples of such are found below and are also described  
in US patent no. 3,251,742 (Revlon), the contents of which are  
incorporated herein by reference.

30 Optionally dyeing compositions (especially hair dyeing com-  
positions) of the invention also comprise a modifier (coupler)  
by which a number of colour tints can be obtained.

In general modifiers are used in dyeing composition for hair as  
the hair colours resulting from hair dyeing compositions  
35 without modifier(s) are usually unacceptable for most people.

Modifiers are typically m-diamines, m-aminophenols, or poly-  
phenols. Upon the optional addition of a modifier (coupler) it

reacts with the dye precursor(s) in the presence of e.g. a laccase, converting the dye precursor(s) into a coloured compound.

Examples of modifiers (couplers) include m-phenylene-diamine, 2,4-diaminoanisole, 1-hydroxynaphthalene( $\alpha$ -naphthol), 1,4-dihydroxybenzene(hydroquinone), 1,5-dihydroxynaphthalene, 1,2-dihydroxybenzene(pyrocatechol), 1,3-dihydroxybenzene (resorcinol), 1,3-dihydroxy-2-methylbenzene, 1,3-dihydroxy-4-chlorobenzene(4-chlororesorcinol), 1,2,3-trihydroxybenzene, 1,2,4-trihydroxybenzene, 1,2,4-trihydroxy-5-methylbenzene, 1,2,4-trihydroxytoluene.

When using the dyeing compositions of the invention a reduced amount of enzyme (i.e. mg enzyme protein per ml dyeing composition) is needed to obtain the maximal dyeing effect (See Figure 1 and Figure 4), determined as the optimal  $\Delta E^*$ -value, in comparison to prior art dyeing compositions, such as dyeing compositions comprising a laccase derived from *Rhus*.

The amount of dye precursor(s) and other ingredients used in the composition of the invention are in accordance with usual commercial amounts.

According to the invention the product comprising the dyeing composition may be a one or a two compartment product. In the one compartment product the laccase, the dye precursor(s) and other ingredients are kept together in a stabilised solution or kept under stable conditions (i.e. the dye precursors are not oxidised by the laccase). In a two compartment product the laccase and the dye precursor(s) and other ingredients are kept in two containers kept apart. The contents of said containers are mixed immediately before use.

### 30 USE

In the second aspect the invention relates to the use of the dyeing composition of the invention for permanent dyeing of keratinous fibres, in particular hair, fur, hide and wool.

When using a dying composition of the invention the  $\Delta E^*$ -value obtained is higher than that of a dyeing composition comprising a laccase derived from genus *Rhus* under corresponding dyeing conditions (see Figure 1).

### Method

In the third aspect the invention relates to a method for permanent dyeing of keratinous fibres comprising contacting a dyeing composition of the invention with the keratinous fibres in question under suitable conditions and for a period of time sufficient to permit oxidation of the dye precursor into a coloured compound.

The dyeing procedure may be carried out at room temperature, preferably around the optimal temperature of the enzyme, typically with from 10 to 60°C; at a pH in the range from 3 to 10, preferably 5 to 9, especially 6 to 8; for a period of time between 10 and 60 minutes, preferably 15 to 50 minutes, especially 20 to 40 minutes.

When using the method of the invention the  $\Delta E^*$ -value obtained is higher than that of corresponding methods where a laccase derived from a strain of the genus *Rhus* are used under the same dyeing conditions, in the presence or absence of at least one modifier, with at least one dye precursor, for a period of time, and under conditions sufficient to permit oxidation of the dye precursor used for oxidising the dye.

The method can be conducted with one or more dye precursors, either alone or in combination with one or more modifiers.

### **MATERIALS AND METHODS**

#### **Materials:**

##### Hair:

6" De Meo Virgin Natural White Hair (De Meo Brothers Inc. USA)

##### Enzymes:

*Myceliophthora thermophila* laccase described in WO 95/33836 (PCT/US95/06815) from Novo Nordisk Biotech, Inc.

*Myceliophthora thermophila* T1 variant laccase described in US patent application 60/003,142 from Novo Nordisk Biotech, Inc.

*Polyporus pinsitus* laccase described in WO 96/00290 (PCT/US95/07536) from Novo Nordisk Biotech, Inc.

*Rhus vernicifera* laccase (Yoshida, J. Chem. Soc., 472 (1883)

*Rhizoctonia solani* laccase described in WO 95/07988 from Novo Nordisk Biotech, Inc.

*Scytalidium thermophilum* laccase described in WO 95/33837 (PCT/US95/06816) from Novo Nordisk Biotech, Inc.

Deposit of Biological Material

5 The following biological material has been deposited on the 25 May 1994 under the terms of the Budapest Treaty with the Agricultural Research Service Patent Culture Collection, Northern Regional Research Center, 1815 University Street, Peoria, Illinois, 61604 and given the following accession  
10 number.

<u>Deposit</u>	<u>Accession Number</u>
<i>E. coli</i> JM101 containing pRaMB5	NRRL B-21261

15 Dye precursors:

0.1 % w/w p-phenylene-diamine in 0.1 M K-phosphate buffer, pH 7.0. (pPD)  
0.1 % w/w p-toluylene-diamine in 0.1 M K-phosphate buffer, pH 7.0.  
20 0.1 % w/w chloro-p-phenylenediamine in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w p-aminophenol in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w o-aminophenol in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w 3,4-diaminotoluene in 0.1 M K-phosphate, buffer pH  
25 7.0.

Modifiers:

0.1 % w/w m-phenylenediamine in 0.1 M K-phosphate buffer, pH 7.0.  
30 0.1 % w/w 2,4-diaminoanisole in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w alpha-naphthol in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w hydroquinone in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w pyrocatechol in 0.1 M K-phosphate buffer, pH 7.0.  
35 0.1% w/w resorcinol in 0.1 M K-phosphate buffer, pH 7.0.  
0.1 % w/w 4-chlororesorcinol in 0.1 M K-phosphate buffer, pH 7.0.

The dye precursor is combined with one of the above indicated modifiers so that the final concentration in the dyeing solution is 0.1 % w/w with respect to precursor and 0.1 % w/w with respect to modifier.

5

Other solutions:

Commercial shampoo

Equipment:

10 Minolta CR200 Chroma Meter

Determination of Laccase Activity (LACU)

Laccase activity is determined from the oxidation of syringaldazin under aerobic conditions. The violet colour produced is photometered at 530 nm. The analytical conditions are 19 mM syringaldazin, 23.2 mM acetate buffer, pH 5.5, 30°C, 1 min. Reaction time.

1 laccase unit (LACU) is the amount of enzyme that catalyses the conversion of 1.0 micromole syringaldazin per minute at these conditions.

Assessment of the hair colour

The quantitative colour of the hair tresses is determined on a Minolta CR200 Chroma Meter by the use the parameters L\* ("0"=black and "100"=white), a\* ("-"=green and "+"=red) and b\* ("-" blue and "+" yellow).

$\Delta L^*$ ,  $\Delta a^*$  and  $\Delta b^*$  are the delta values of L\*, a\* and b\* respectively compared to L\*, a\* and b\* of untreated hair (e.g.  $\Delta L^* = L^*_{\text{sample}} - L^*_{\text{untreated hair}}$ ).

$\Delta E^*$  is calculated as  $\Delta E^* = \sqrt{(\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})}$  and is an expression for the total quantitative colour change.

**EXAMPLES**35 **Example 1**Dyeing effect



The dyeing effect of different laccases were tested and compared under the same conditions using 0.1% w/w o-aminophenol (dye precursor) and 0.1% w/w m-phenylene-diamine (modifier).

The laccases tested were

- 5 a *Polyporus pinsitus* laccase,
- a *Myceliophthora thermophila* laccase
- a *Myceliophthora thermophila* T1 laccase variant,
- a *Rhus vernicifera* laccase
- a *Rhizoctonia solani* laccase
- 10 a *Scytalidium thermophila* laccase

#### Hair dyeing

1 gram white De Meo hair tresses were used.

- 4 ml dye precursor solution (including modifier) was mixed
- 15 with 1 ml laccase on a Whirley mixer, applied to the hair tresses and incubated at 30°C for 60 minutes.

The hair tresses were then rinsed with running water, washed with shampoo, rinsed with water, combed, and air dried.

- a\*, b\* and L\* were determined on the Chroma Meter and  $\Delta E^*$
- 20 was then calculated.

Hair tress samples treated without enzyme were used as a blind.

The result of the test is displayed in figure 1.

#### 25 **Example 2**

##### Wash stability

- Tresses of white De Meo hair (1 gram) were used for testing
- of the wash stability of hair dyed using the *Myceliophthora thermophila* T-variant laccase and the *Polyporus pinsitus*
- 30 laccase.

Oxidative hair dyeing was carried out as described in Example 1, except that p-phenylene-diamine (pPD) were used as the dye precursor and no modifiers were used.

#### 35 Hair wash

The dyed hair tresses were wetted and washed for 15 seconds with 50 ml of commercial shampoo, and rinsed with water for 1

minute and air dried. The hair tresses were washed up to 18 times.

Then  $a^*$ ,  $b^*$  and  $L^*$  were determined on the Chroma Meter and  $\Delta E^*$  values were then calculated.

- 5 Hair tress samples treated without enzymes were used as blinds.

The result of the test is displayed in figure 2.

### Example 3

#### 10 Fastness of hair dyeing

Tresses of white De Meo hair (1 gram) were used for testing fastness (speed) of hair dyeing using the *Myceliophthora thermophila* T1 variant laccase and the *Polyporus pinsitus* laccase.

- 15 p-phenylene-diamine (PPD) was used as the dye precursor and no modifiers were used.

4 ml dye precursor solution was mixed with 1 ml laccase on a Whirley mixer, applied to the hair tresses and incubated at 30°C for 10, 20, 30, 40, 50 and 60 minutes, respectively.

- 20 The hair tresses were then rinsed with running water, washed with shampoo, rinsed with running water, combed, and air dried.

$a^*$ ,  $b^*$  and  $L^*$  were determined on the Chroma Meter for each incubation time and the  $\Delta E^*$ -values were then calculated.

- 25 Hair tress samples treated without enzymes for 60 minutes were used as blinds.

The result of the test is displayed in figure 3.

### Example 4

#### Dyeing effect of *Myceliophthora thermophila* T1 variant laccase

- 30 The dyeing effect of *Myceliophthora thermophila* T1 variant laccase were compared with the *Polyporus pinsitus* laccase using 0.1% w/w p-phenylene-diamine, 0.1% w/w p-touylene-diamine, 0.1% w/w chloro-p-phenylene-diamine, 0.1% w/w p-aminophenol, 0.1% w/w o-aminophenol and 0.1% w/w 3,4 diaminotoluene, respectively,  
35 ly, as dye precursors.

The *Polyporus pinsitus* laccase were applied in a concentration of 10 LACU/ml while the *Myceliophthora*

*thermophila* T1 variant laccase was applied in a concentration of only 1 LACU/ml.

1 gram white De Meo hair tresses were used.

4 ml dye precursor solution was mixed with 1 ml laccase on a Whirley mixer, applied to the hair tresses and incubated at 30°C for 60 minutes.

The hair tresses were then rinsed with running water, washed with shampoo, rinsed with running water, combed, and air dried.

The  $a^*$ ,  $b^*$  and  $L^*$  were determined on the Chroma Meter and the  $\Delta E^*$  values were then calculated.

Hair tress samples treated without enzyme were used as blinds.

The result of the test is displayed in Table 1.

Table 1

Sample	<i>Polyporus pinsitus</i> laccase $\Delta E^*$	<i>Myceliophthora thermophila</i> T1 variant laccase $\Delta E^*$
p-phenylene-diamine blind	9.7	10.9
p-phenylene-diamine + laccase	52.7	52.9
p-toluylene-diamine blind	16.1	18.6
p-toluylene-diamine + laccase	39.1	38.2
chloro-p-phenylene-diamine blind	2.6	4.0
chloro-p-phenylene-diamine + laccase	40.5	39.2
p-aminophenol blind	6.2	7.0
p-aminophenol + laccase	32.4	28.1
o-amonophenol blind	5.6	6.4
o-amonophenol + laccase	22.9	22.0
3,4-diaminotoluene blind	3.4	2.6
3,4-diaminotoluene + laccase	36.5	42.2

As can be seen from Table 1 compositions comprising the *Myceliophthora thermophila* T1 laccase variant dyes the hair as good as the *Polyporus pinsitus* laccase even though

concentration of the *Polyporus pinsitus* laccase is 10 time higher.

#### Example 5

##### 5 Dose-response dyeing effect of *M. thermophila* laccase

The dyeing effect of *M. thermophila* laccase were tested using concentration between 0.0001 to 0.5 mg enzyme protein per ml dyeing composition of laccase. 0.1% w/w p-toluylene-diamine (PTD) was used as the dye precursor.

- 10 The same dyeing procedure as described in Example 1 was used. The result of the tests are displayed in Figure 4.

## SEQUENCE LISTING

(1) GENERAL INFORMATION:

(i) APPLICANT:

(A) NAME: Novo Nordisk A/S

(B) STREET: Novo Alle

(C) CITY: Bagsvaerd

(D) COUNTRY: Denmark

(E) POSTAL CODE (ZIP): DK-2880

(F) TELEPHONE: +45 4444 8888

(G) TELEFAX: +45 4449 3256

(ii) TITLE OF INVENTION: Laccases with improved dyeing properties

(iii) NUMBER OF SEQUENCES: 2

(v) COMPUTER READABLE FORM:

(A) MEDIUM TYPE: Floppy disk

(B) COMPUTER: IBM PC compatible

(C) OPERATING SYSTEM: PC-DOS/MS-DOS

(D) SOFTWARE: PatentIn Release #1.0, Version #1.30

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:

(A) LENGTH: 3192 base pairs

(B) TYPE: nucleic acid

(C) STRANDEDNESS: single

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(ix) FEATURE:

(A) NAME/KEY: CDS

(B) LOCATION: join(586..831, 917..994, 1079..1090, 1193..1264, 1337..2308, 2456..2524, 2618..3028)

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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TCATCGAGCG AGTGATCTCC ACCACCCAGA AGGGAGGGGG GATGCGCGCA TGCTCCAACA	180
TCCCTGGTGT CGCTAGAGAC GTCGCGGCAT CAGCCTTTTC ATCACACCGA GCACGTCCAC	240
GGACCGGCTC CTTTCACCCC CGCGTCCTCC GGAGGATTGA GTCACGATAT TTCGGGATGT	300
GGGAAGGGGG AGAGAAAGGA GGGGGGAGGG GCGGAAACAT GTTGATACG AGCTGCGCCC	360
CTTTTCAAC ATCGAGAACA GGAAGTCGTT GGTGTCGGCC GTAATGTCTA TAAAACGAGG	420
CTCCTTCTCG TCGTCGACTT GTCTCAGGTT CTCTCTCTCG TCCACACCAA GCCAGTCTTG	480
CCTGAGCCAC CTGAGCCACC TTCAACTCAT CATCTTCAGT CAAGTCGTTC ATTGACATTG	540
TGTCTCTCTT TCTATCGAGT CGGCTTCCCG GCCCTTCACC ACAAC ATG AAG TCC	594
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5 10 15	

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15	ACC GAC TAC GAA GTG GAC AGC CCG GAC ACG GGT GTT GTT CGG CCG	831
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20	CTAAGCAGGA GCTGACATGC GACAG TAC ACT CTG ACT CTC ACC GAA GTC GAC	943
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	85 90	
25	AAC TGG ACC GGA CCT GAT GGC GTC GTC AAG GAG AAG GTC ATG CTG GTT	991
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	CCCTGAGAGA GACTGACCGA GCCTTTGGCT GCAG AAT AGT ATA ATC GTAATTAATT	1100
	Asn Ser Ile Ile	
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35	ATACCGCCCT GCCTCCAGCA GCCCCAGCAG CTCGAGAAGG GTATCTGAAG TTAGTCAGGC	1160
	CTGCTGACCT GACCGGGGCC AACCCACCAT AG GGA CCA ACA ATC TTT GCG GAC	1213
	Gly Pro Thr Ile Phe Ala Asp	
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40	TGG GGC GAC ACG ATC CAG GTA ACG GTC ATC AAC AAC CTC GAG ACC AAC	1261
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	Gly	
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	GGC GTG GTC GGG GCC ATT CAG ATC AAC GGG CCG GCC TCG CTG CCG TAC	1558
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10	GAC AAC GTC CTG TTC AAC GGC ACG GCC AAG CAC CCG GAG ACG GGC GAG	1702
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	260 265 270	
20	CGC CTG ATC AAC ACG TCG GTC GAG AAC CAC TTC CAG GTC TCG CTC GTC	1798
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	275 280 285 290	
	AAC CAC ACC ATG ACC ATC ATC GCC GCC GAC ATG GTG CCC GTC AAC GCC	1846
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25	ATG ACG GTC GAC AGC CTC TTC CTC GGC GTC GGC CAG CGC TAC GAT GTC	1894
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30	GTC ATC GAA GCC AGC CGA ACG CCC GGG AAC TAC TGG TTT AAC GTC ACA	1942
	Val Ile Glu Ala Ser Arg Thr Pro Gly Asn Tyr Trp Phe Asn Val Thr	
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35	TTT GGC GGC GGC CTG CTC TGC GGC GGC TCC AGG AAT CCC TAC CCG GCC	1990
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40	GCC ATC TTC CAC TAC GCC GGC GCC CCC GGC GGC CCG CCC ACG GAC GAG	2038
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	455 460	
65	GGGGTGCTGC TGCAAGTACA CCTTGCTCGC CCTCCTGTTC TTCCTTAATA ACTACCTCCC	2388
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5 TTTGCAG TGG TCG TAC TGG TTG ATC GAG AAC GAT CCC GGC GCA CCT TTC 2497  
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60 AGGAAAAGG AAACAAAGAG GGGGGGGGGG GCTAGTTCCT ATTTTGTCTT TTTTTTTTGTG 3098  
     TTCTTGTCCT TGTGCTGGCG GTTACCCTGG TAAAGGAGAA GGGGGCCCCA AGTTCGAGTG 3158  
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## (2) INFORMATION FOR SEQ ID NO:2:

60 (i) SEQUENCE CHARACTERISTICS:  
     (A) LENGTH: 620 amino acids  
     (B) TYPE: amino acid  
     (D) TOPOLOGY: linear

65 (ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

Met Lys Ser Phe Ile Ser Ala Ala Thr Leu Leu Val Gly Ile Leu Thr



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	His	Leu	His	Gly	His	Asp	Phe	Tyr	Val	Leu	Gly	Arg	Ser	Pro	Asp	Glu
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25	Ser	Pro	Ala	Ser	Asn	Glu	Arg	His	Val	Phe	Asp	Pro	Ala	Arg	Asp	Ala
				500					505					510		
	Gly	Leu	Leu	Ser	Gly	Ala	Asn	Pro	Val	Arg	Arg	Asp	Val	Thr	Met	Leu
			515					520					525			
30	Pro	Ala	Phe	Gly	Trp	Val	Val	Leu	Ala	Phe	Arg	Ala	Asp	Asn	Pro	Gly
		530					535					540				
35	Ala	Trp	Leu	Phe	His	Cys	His	Ile	Ala	Trp	His	Val	Ser	Gly	Gly	Leu
	545					550					555					560
	Gly	Val	Val	Tyr	Leu	Glu	Arg	Ala	Asp	Asp	Leu	Arg	Gly	Ala	Val	Ser
					565					570					575	
40	Asp	Ala	Asp	Ala	Asp	Asp	Leu	Asp	Arg	Leu	Cys	Ala	Asp	Trp	Arg	Arg
				580					585					590		
	Tyr	Trp	Pro	Thr	Asn	Pro	Tyr	Pro	Lys	Ser	Asp	Ser	Gly	Leu	Lys	His
			595					600					605			
45	Arg	Trp	Val	Glu	Glu	Gly	Glu	Trp	Leu	Val	Lys	Ala				
	610						615					620				

# INDICATIONS RELATING TO A DEPOSITED MICROORGANISM

(PCT Rule 13 bis)

A. The indications made below relate to the microorganism referred to in the description on page <u>13</u> , line <u>4-13</u> :	
B. IDENTIFICATION OF <span style="float: right;">Further deposits are identified on an additional sheet <input type="checkbox"/></span>	
Name of depository institution Agricultural Research Service Patent Culture Collection (NRRL)	
Address of depository institution (including postal code and country)  Northern Regional Research Center 1815 University Street Peoria, IL 61604, US	
Date of deposit 25 May 1994	Accession Number NRRL B-21261
C. ADDITIONAL INDICATIONS (leave blank if not applicable) <span style="float: right;">This information is continued on an additional sheet <input type="checkbox"/></span>	
In respect of those designations in which a European and/or Australia Patent is sought, during the pendency of the patent application, a sample of the deposited microorganism is only to be provided to an independent expert nominated by the person requesting the sample (Rule 28(4) EPC/Regulation 3.25 of Australia Statutory Rule 1991 No. 71).	
D. DESIGNATED STATES FOR WHICH INDICATIONS ARE MADE (if the indications are not for all designated States)	
E. SEPARATE FURNISHING OF INDICATIONS (leave blank if not applicable)	
The indication listed below will be submitted to the International Bureau Later (specify the general nature of the indications e.g. "Accession Number of Deposit")	

For receiving Office use only

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## PATENT CLAIMS

1. A dyeing composition comprising
  - a) above 0 to 1 mg enzyme protein per ml dyeing composition of
  - 5 microbial laccase,
  - b) one or more dye precursor, and
  - c) optionally one or more dye modifiers.
2. The dyeing composition according claims 1, wherein the laccase is presents in a concentration of from 0.0001 to 1  
10 mg/ml, preferably 0.001 to 0.8 mg/ml, more preferred 0.002 to 0.5 mg/ml, even more preferred 0.003 to 0.2 mg/ml, especially 0.004 to 0.1 mg enzyme protein/ml dyeing composition.
3. The dyeing composition according to claims 1 and 2, wherein said microbial laccase is of filamentous fungus origin.
- 15 4. The dyeing composition according to claims 1 and 2, wherein the laccase is derived from a strain of the genus *Myceliophthora*, in particular a strain of species *Myceliophthora thermophila*, such as *Myceliophthora thermophila* NRRL B 21261, or variants thereof, such as the T1 variant.
- 20 5. The dyeing composition according to claim 4, wherein the laccase is encoding by the sequence shown in SEQ ID NO 1.
6. The dyeing composition according to claims 4 and 5, wherein the laccase is present in a concentration of from above 0 to 1 mg/ml, preferably 0.0001 to 0.1 mg/ml, more preferably  
25 0.0005 to 0.05 mg/ml, especially 0.001 to 0.01 mg enzyme protein/ml dyeing composition.
7. The dyeing composition according to any of claims 1 to 6, comprising a dye precursor selected from the group comprising p-phenylene-diamine (PPD), p-toluylene-diamine (PTD), chloro-p-phenylenediamine, p-aminophenol, o-aminophenol, 3,4-diamino-  
30 toluene, 2-methyl-1,4-diaminobenzene, 4-methyl-o-phenylenediamine, 2-methoxy-p-phenylenediamine, 2-chloro-1,4-diamino-benzene, 4-amino diphenylamine, 1-amino-4- $\beta$ -methoxyethylamino-benzene, 1-amino-4-bis-( $\beta$ -hydroxyethyl)-amonibenzene, 1-3-diamino-  
35 benzene, 2-methyl-1,3-diamino-benzene, 2,4-diaminotoluene, 2,6-diaminopyridine, 1-hydroxy-2-amino-benzene, 1-hydroxy-3-amino-benzene, 1-methyl-2-hydroxy-4-amino-benzene, 1-methyl-2-hydro-

xy-4- $\beta$ -hydroxyethylamino-benzene, 1-hydroxy-4-amino-benzene, 1-hydroxy-4-methylamino-benzene, 1-methoxy-2,4-diamino-benzene, 1-ethoxy-2,3-diamino-benzene, 1- $\beta$ -hydroxyethyloxy-2,4-diamino-benzene, phenazines, such as 4,7-phenazinedicarboxylic acid, 2,7-phenazinedicarboxylic acid, 2-phenazinecarboxylic acid, 2,7-diaminophenazine, 2,8-diaminophenazine, 2,7-diamino-3,8-dimethoxyphenazine, 2,7-diamino-3-methoxyphenazine, 2,7-diamino-3-methoxyphenazine, 3-dimethyl 2,8-phenazinediamine, 2,2'-[(8-amino-7-methyl-2-phenazinyl)imino]bis-ethanol, 2,2'-[(8-amino-7-methoxy-2-phenazinyl)imino]bis-ethanol, 2,2'-[(8-amino-7-chloro-2-phenazinyl)imino]bis-ethanol, 2-[(8-amino-7-methyl-2-phenazinyl)amino]-ethanol, 2,2'-[(8-amino-2-phenazinyl)imino]-bis-ethanol, 3-amino-7-(dimethylamino)-2,8-dimethyl-5-phenyl-chloride, 9-(diethylamino)- benzo[a]phenazine-1,5-diol, N-[8-(diethylamino)-2-phenazinyl]- methanesulfonamide, N-(8-methoxy-2-phenazinyl)-methanesulfonamide, N,N,N',N'-tetramethyl-2,7-phenazinediamine, 3,7-dimethyl-2-phenazinamine, p-amino benzoic acids, such as p-amino benzoic acid ethyl, p-amino benzoic acid glycerid, p-amino benzoic acid isobutyl, p-dimethylamino benzoic acid amil, p-dimethylamino benzoic acid octyl, p-diethoxy amino benzoic acid amil, p-dipropoxy amino benzoic acid ethyl, acetylsalicylic acid, isatin derivatives, such as 2,3-diamino benzoic acid.

8. The dyeing composition according to any of claims 1 to 7, comprising a dye modifier selected from the group comprising m-phenylene-diamine, 2,4-diaminoanisole, 1-hydroxynaphthalene( $\alpha$ -naphthol), 1,4-dihydroxybenzene(hydroquinone), 1,5-dihydroxynaphthalene, 1,2-dihydroxybenzene(pyrocatechol), 1,3-dihydroxybenzene (resorcinol), 1,3-dihydroxy-2-methylbenzene, 1,3-dihydroxy-4-chlorobenzene (4-chlororesorcinol), 1,2,3, trihydroxybenzene, 1,2,4-trihydroxybenzene, 1,2,4-trihydroxy-5-methylbenzene, 1,2,4-trihydroxytoluene.

9. Use of the composition according to claim 1 to 8 for permanent dyeing of keratinous fibres, such as hair, fur, hide or wool.

10. A method for dying keratinous fibres comprising contacting a dyeing composition according to claims 1 to 8 to

the keratinous fibres under suitable conditions and for a period of time sufficient to permit oxidation of the dye precursor into a coloured compound.

11. The method according to claim 10, wherein the dyeing  
5 procedure is carried out at a pH in the range from 3 to 10, preferably 5 to 9, especially 6 to 8.

12. The method wherein according to claims 10 and 11,  
wherein the procedure is carried out for a period of time  
between 10 and 60 minutes, preferably 15 to 50 minutes,  
10 especially 20 to 40 minutes.

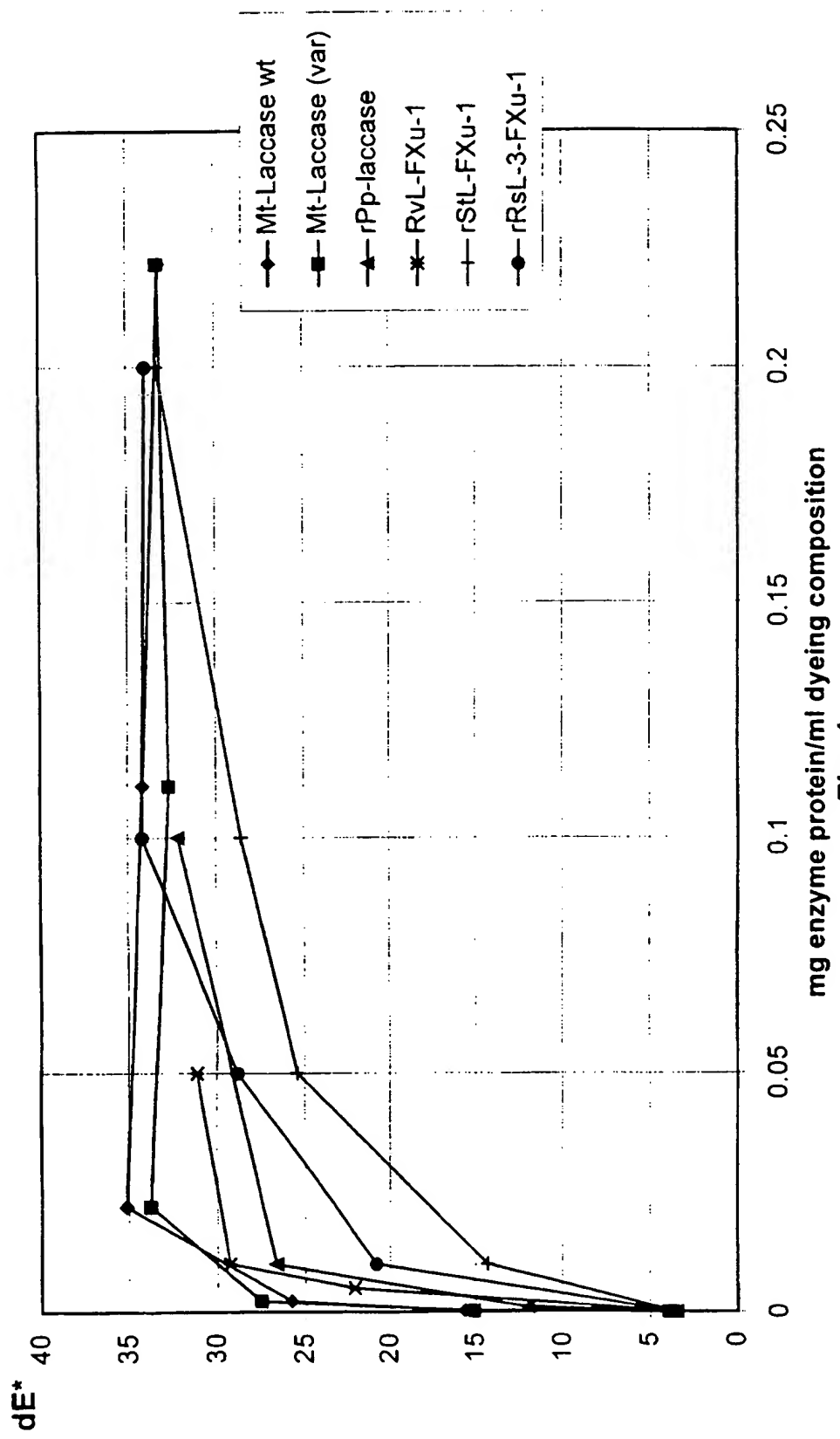
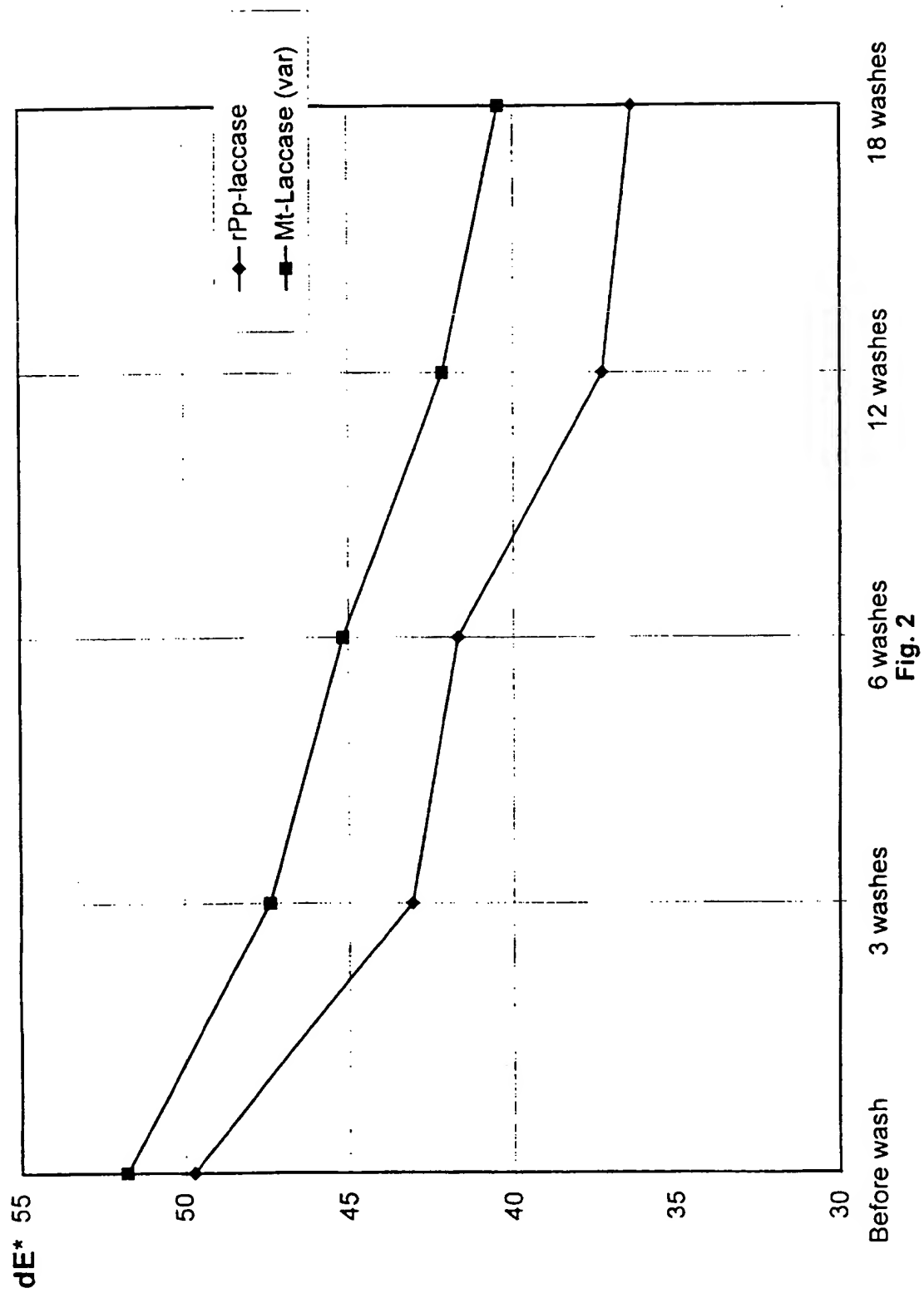


Fig. 1





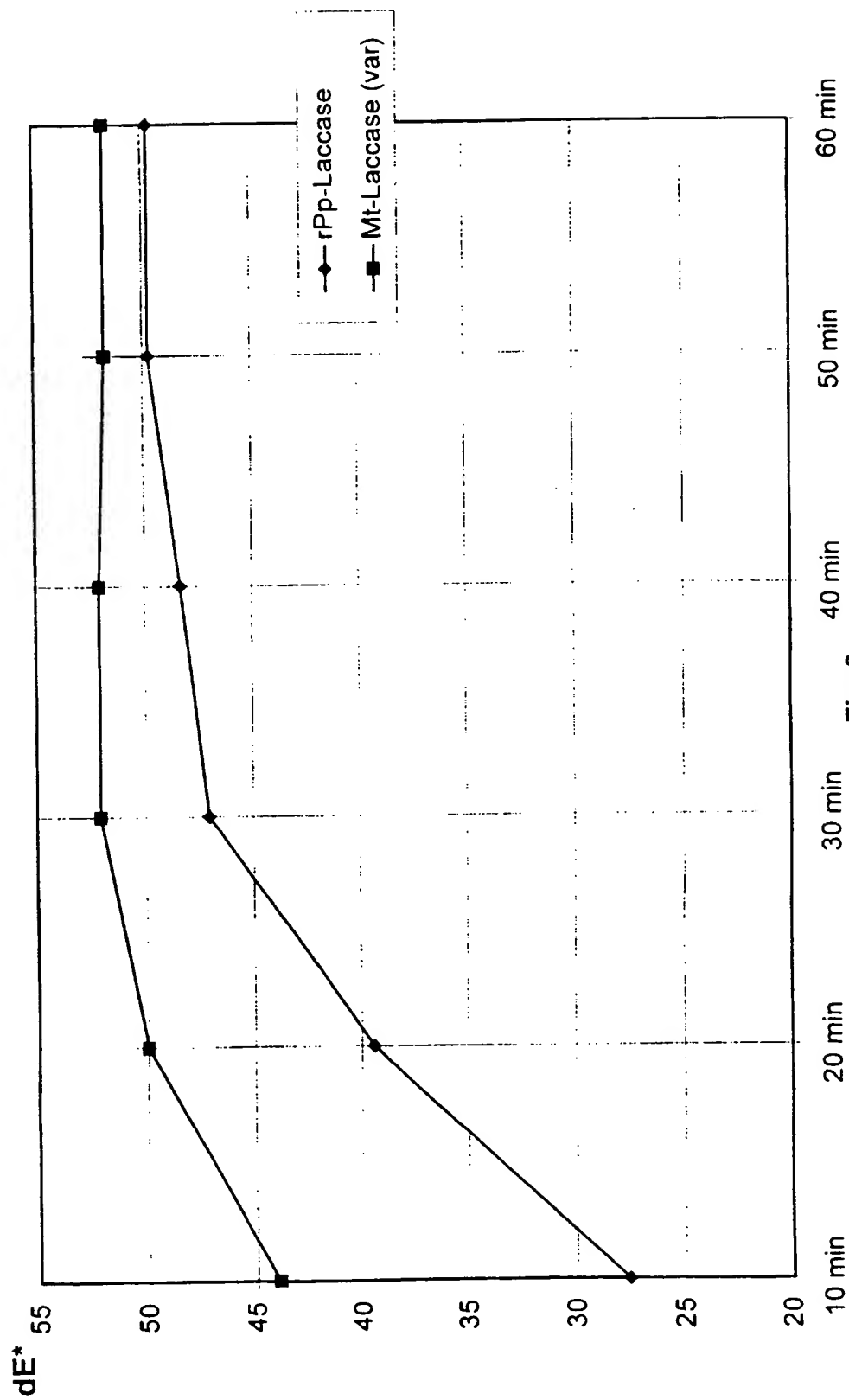
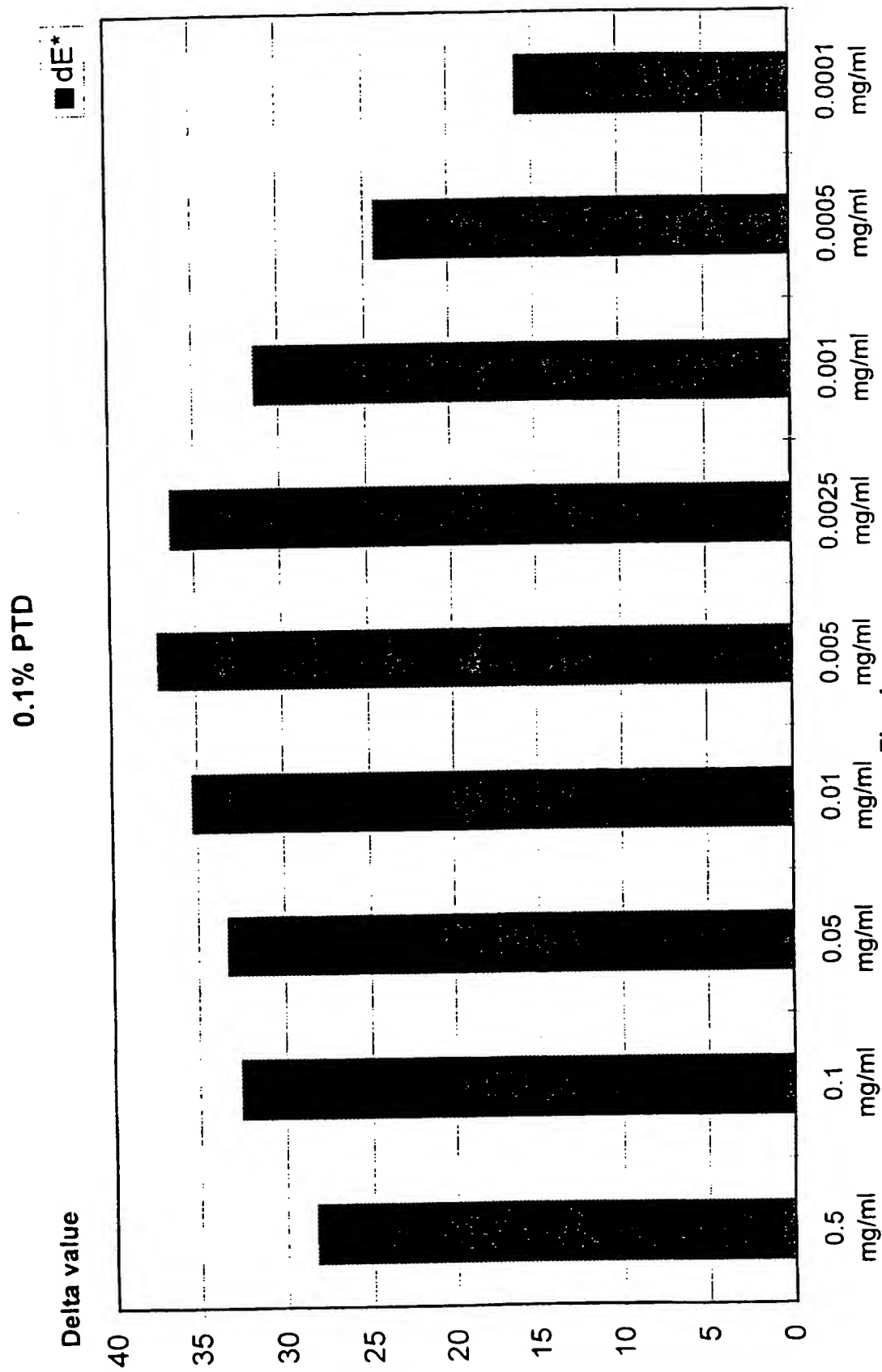


Fig. 3



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 96/00499

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: C09B 67/00, A61K 7/13

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: C09B, A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 9533836 A1 (NOVO NORDISK BIOTECH, INC.), 14 December 1995 (14.12.95), claims 31-42; page 16, line 12 - page 17, line 27; page 34, line 20 - page 36 --	1-12
P,X	WO 9533837 A1 (NOVO NORDISK BIOTECH, INC.), 14 December 1995 (14.12.95), claims 28, 29; page 15, line 34 - page 16, line 2 --	1-3
P,A	--	4-12
X	EP 0504005 A1 (PERMA SOCIETE ANONYME), 16 Sept 1992 (16.09.92) --	1-3
A	--	4-12

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

## \* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "B" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

28 February 1997

Date of mailing of the international search report

01-03-1997

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 96/00499

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	--	4-12
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X	STN International, File CAPLUS, CAPLUS accession no. 1995:974547, Chivukula, Muralikrishna et al: "Phenolic azo dye oxidation by laccase from Pyricularia oryzae"; & Appl. Environ. Microbiol. (1995), 61(12), 4374-77	1-3
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Information on patent family members

03/02/97

International application No.

PCT/DK 96/00499

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		US-A- 5538517	23/07/96